ORIGINAL ARTICLE

Outdoor Air Pollution and Emergency Room Visits at a Hospital in Delhi

J.N. Pande, Narendra Bhatta, Dilip Biswas[1], Ravindra M. Pandey[2],
Gautam Ahluwalia, Naveen H. Siddaramaiah and G.C. Khilnani

Departments of Medicine and Biostatistics[2], All India Institute of Medical Sciences, New Delhi
and Central Pollution Control Board’, New Delhi

ABSTRACT

Several reports from large metropolitan cities have indicated significant association between acute morbidity and mortality from cardio-respiratory disorders and daily levels of major pollutants in the ambient air. Despite the wide-spread public concern about the adverse health effects of air pollution, there is substantial uncertainty regarding the effects of these pollutants at a concentration typical of Delhi, which is one of the ten most polluted cities in the world and the most polluted city in India. This study was undertaken to correlate the daily levels of various pollutants with the number of patients visiting the All India Institute of Medical Sciences (AIIMS, New Delhi) casualty for aggravation of certain defined cardiorespiratory disorders. Daily counts of patients visiting the emergency room of the AIIMS for acute asthma, acute exacerbation of chronic obstructive airway disease (COAD) and acute coronary event was obtained in prospective manner from January 1997 to December 1998. Daily mean levels of ambient CO, NO_x and SO, were monitored along with temperature and humidity. Data was analysed using one day time lag for events of interest. Time series analysis was undertaken using Poisson regression and population averaged general estimation equation, correcting for auto-correlation, days of the weak and season. The ambient levels of pollutants exceeded the national air quality standards on most of the days, over the two year period. Further, emergency room visits for asthma, COAD and acute coronary events increased by 21.30%, 24.90% and 24.30% respectively on account of higher than acceptable levels of pollutants. It is concluded that there is considerable burden of cardiorespiratory diseases in Delhi due to high levels of ambient air pollution.

Key words *: Air pollution, Asthma, Acute coronary events, Cardiopulmonary disease, COAD.*

[Indian J Chest Dis Allied Sci 2002; 44 : 13-19]

INTRODUCTION

There is a growing concern about increasing outdoor air pollution in several metropolitan cities with high vehicular density’. This is particularly true for developing countries where the emission standards for motor vehicles, the major source of air pollution, are lax or non-existent. Several reports from North America[1,2], Europe[3] and Australia[4] have indicated significant association between acute morbidity and mortality from cardiopulmonary diseases

---

Correspondence : J.N. Pande, Professor and Head, Department of Medicine, All India Institute of Medical Sciences, Ansari Nagar, New Delhi-110 029; E-mail : <jnpande@hotmail.com>.

and the levels of major pollutants in the ambient air monitored on daily basis in large cities. Delhi has witnessed an unprecedented increase in the number of motor vehicles in the last decade and has acquired the status of being amongst the most polluted cities of the world[5]. Based on the data on excess mortality with increasing air pollution from the west, alarming projections regarding deaths from air pollution in Delhi have been made in the press and other media. Concern groups such as the Center for Science and Environment have created public awareness regarding the ill effects of air pollution resulting in judiciary taking a note of the matter and enforcing emission norms for the motor vehicles. Much of the information regarding adverse health effects is from developed countries where the prevailing levels of pollutants in the ambient air are relatively low. Similar data from Delhi or other major cities in India are not available. We report here our observations on emergency room visits to All India Institute of Medical Sciences Hospital, New Delhi for acute exacerbation of chronic obstructive airways disease, acute severe asthma, and acute coronary event in relation to the levels of ambient air pollution during the period Jan 1st 1997 to Dec 31st 1998.

MATERIAL AND METHODS

Casualty Visits. Records of patients having visited the Casualty Outpatient Department of AIIMS were scrutinized by a physician for counting events of interest on a daily basis starting 1st January 1997 in a prospective manner. AIIMS is a tertiary care hospital with approximately 1200 hospital beds located in south Delhi. It is one of the four large Government Hospitals with free beds. Almost 150 patients visit the emergency room every day. The following three categories of patients were counted for analysis of events : 1. Acute exacerbation of chronic obstructive airways disease (COAD), 2. Acute asthmatic attack requiring nebulized bronchodilator therapy and 3. Acute coronary event defined as acute myocardial infarction, unstable angina or acute left ventricular failure due to ischemic heart disease. Only some of these patients were hospitalized on account of shortage of hospital beds or rapid improvement in the general condition within a few hours of starting the treatment on observation beds. A patient visiting the hospital more than once in 24 hours was counted as one.

Measurement of Pollutant Levels. These measurements were made by the Central Pollution Control Board (CPCB). Data were obtained at a monitoring site located at one of the more heavily polluted areas near a traffic intersection. Total suspended particles (TSP) were estimated by the gravimetric method using a high flow respirable dust sampler (Envirotech APM 460, New Delhi) for 12 to 24 hours. The levels of sulfur dioxide (SO,), oxides of nitrogen (NOx) were obtained by wet chemical methods[6] (West-Gaeke, 1980, Jacob Hochheiser, 1976). Carbon monoxide (CO) level was monitored continuously using nondispersive infrared CO analyzer (WHO, 1976). Meteorological data including temperature and humidity were recorded continuously at the monitoring station using appropriate devices. The results of TSP, CO, SO, and NO, measurements were tabulated as daily time weighted averages. Temperature was calculated as time weighted average, while relative humidity was the mean of maximum and minimum values recorded in 24 hours.

Analysis of Results. Missing data for some of the pollutants on certain days were generated by linear interpolation between the nearest values[7]. Comparison of mean values of pollutant levels, meteorological data, and events of interest for the years 1997 and 1998 was done using Wilcoxon rank sum test. Degree of relationship amongst levels of pollutants, temperature, humidity and events of interest was assessed by using Spearman's rho coefficient. A time lag of one day improved the correlation between the levels of pollutants and the observed events. Of the various degrees of time lags tried, one-day lag fitted the data the best in univariate as well as multivariate analyses.

Univariate regression of events of interest on major pollutants was undertaken using linear as well as Poisson regression[7]. Time series analysis of the data was undertaken using Poisson regression and population averaged general estimation equation (GEE), correcting for autocorrelation, day of the week and season. Six categories of season were created for two months period starting from January. The day of the week was categorized as weekday (Monday through Friday) or weekend (Saturday and Sunday). Season and day of the week were treated as categorical variables and included as dummy variables in the model. All four pollutants were initially entered in the model in addition to temperature and humidity. Non-significant variables were dropped in a stepwise fashion while retaining weather parameters. Statistical package STATA version 6.0 was used for data analysis.

Keeping the upper limit of the norm for individual pollutants prescribed by the Central Pollution Control Board (CPCB), New Delhi, for the residential areas in the multivariable regression model, and the ambient temperature, humidity, day of the week and season, we computed 'expected' total as well as disease specific morbidity for each one of the days. Difference between the events actually observed and the calculated events under 'acceptable' conditions gave an estimate of the 'extra events' that could be ascribed to the levels of the pollutants exceeding the 'recommended norms'. Total as well as disease specific extra-events were calculated.

RESULTS

During the year 1997, the TSP, SO, and NO, data were recorded on 248 days (117 missing values), whereas CO levels were monitored on all of 365 days. In 1998, the TSP, SO, and NO, levels were available on 244 days (121 missing values), while CO levels were available for all the days of the year. Temperature and humidity data was available for both the years. Gaps in recorded data never exceeded three days, and there was no special clustering in relation to weekends or holidays. Missing values were generated by linear interpolation between the two nearest values before further data analysis. During the year 1997, the levels of TSP, NO, and CO exceeded the National Ambient Air Quality levels on 360, 80 and 352 days respectively This happened on 353, 75 and 354 days respectively in 1998. The SO, levels were below the acceptable levels on all the days of both years. The mean and standard deviation for the pollutants, temperature, humidity and cardio-respiratory events for the two years are given in table 1. It was noted that in comparison to 1997, the levels of CO, NO, and SO, increased significantly in 1998 along with an increase in the number of cardio-respiratory events. The total number of patients attending the casualty, however, remained unchanged.

Significant direct correlation was observed amongst all the pollutants (Table 2). It was strongest between SO, and NO,. Further, they

Table 1. *Mean level of air pollutants (mean of daily averages for the whole year) and the events of interest for the year 1997 and 1998. Mean values of temperature and humidity are also given.*

Parameter	1997	1998	**P** value*
Temp (c)	24.5k5.7	23.3k5.8	0.0040
Humidity (%)	62.2±10	60.7±13	0.0125
TSP*	409±128	426±174	NS
CO#	4810 ±2375	5450±2927	0.0044
NO_x#	67 ±28	63±22	NS
SO_2#	21±13	25±10	0.0000
Events	18±11	26±22	0.0000

*Wilcoxon's rank-sum test; # microgram/cubic meter; CO = Carbon monoxide; SO, = Sulphur dioxide; NO_x = Oxides of nitrogen; TSP = Total suspended particles.

were all negatively correlated with temperature but bore no correlation with humidity. Cardio-respiratory events were positively correlated with the levels of all the four pollutants measured and relative humidity, and negatively correlated with temperature.

During the year 1997, 50,336 patients visited the casualty outpatient department. Of these, 6,478 had cardio-respiratory events of interest. The corresponding figures for 1998 were 52,268 and 9,334 respectively. Disease-wise break-up of the patients is given in table 3.

November to February are the coldest months in Delhi. The TSP levels were noted to be highest in November and December each year. The levels rose again in May, which is one of the hottest months. Lowest TSP levels were noted from July to September which correspond to the period after the onset of monsoon. Similarly, relatively lower levels during January and February may be' related to brief winter rains in Delhi. Casualty visits with cardio-respiratory events increased sharply in November and December, and declined rapidly in the new year. The daily count of events of interest against the time axis has been shown in figure 1.

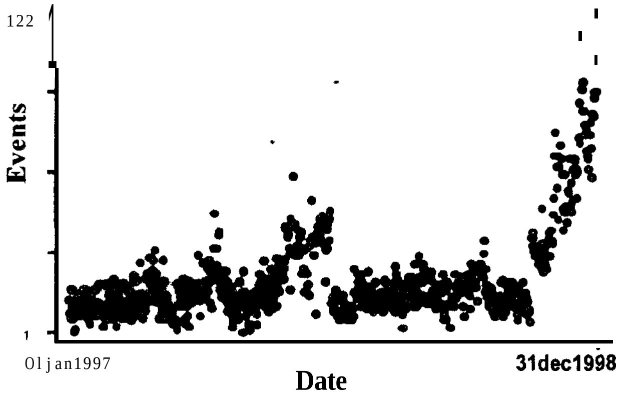

Figure 1. Events plotted against time

Daily events had large dispersion around the mean value (Table 1). Univariate Poisson regression showed all four pollutants to be significantly and positively related to the cardio-respiratory events. Multivariable Poisson regression of events on pollutant levels, temperature, humidity and the total number of patients visiting the casualty resulted in elimination of SO, and NO_x as significant predictors. Analysis of data using general estimation equation (GEE) showed similar results. The odds of extra-events calculated from multivariable Poisson regression model are given in table 4. On an average during the years 1997-98, approximately 22 cardio-respiratory events were encountered daily in the casualty outpatient. It is estimated that almost one fourth of these could be attributed to the ambient levels

Table 2. *Coefficient of correlation as derived by Spearman's rho between events and various parameters.*

	TSP	CO	NO_x	SO_2	Temp	Humidity
Events	0.1809	0.1526	0.1800	0.2265	-0.043"	0.1767
Humidity	–0.0689*	0.1289	0.1861	0.0423*	-0.1177	
Temp	-0.3008	-0.2580	-0.1462	-0.2535		
SO_2	0.4074	0.4170	0.7333			
NO_x	0.3828	0.4539				
CO	0.3527					

All pairs significantly correlated except those marked with*; CO = Carbon monoxide; SO, = Sulpur dioxide; NO_x = Oxides of nitrogen.

Table 3. *Records of patients of cardio-respiratory disease visiting casuality 1997-98.*

Year	Total No. of patients attending casualty	Total cardio-respiratory events	COAD	Asthma	ACE
1997	50336	6478	1240	2138	3100
1998	52268	9334	1944	3151	4239

Table *4. Observed and expected daily (mean ± SD) events 1997-98.*

Disease	Observed	Expected*	Extra	%Increase
Asthma	**7.23 ± 7.82**	**5.96 ± 4.55**	**1.27 ± 4.93**	**21.30**
COAD	**4.37 ± 4.97**	**3.50 ± 2.48**	**0.87 ± 3.34**	**24.90**
ACE	**10.09 ± 7.09**	**8.11 ± 3.07**	**1.97 ± 5.70**	**24.30**
Total	**21.65 ± 17.65**	**17.44 ± 9.54**	**4.20 ± 11.38**	**24.10**

*Calculated by assigning permissible upper level of CO and TSP in the regression model.
COAD = Chronic obstructive airways disease; ACE = acute coronary event.

of pollutants exceeding the upper limits recommended for Delhi by the CPCB. The risk was the greatest for acute exacerbation of chronic obstructive lung disease, acute coronary events and followed by asthma.

DISCUSSION

The influence of daily variation in the level of pollutants on cardio-respiratory morbidity and mortality has been extensively studied in several large cities in the world [8,9]. Among the short-term adverse effects, hospital admissions or emergency room visits for asthma, chronic obstructive airways disease, or acute coronary events have been reported to be related to ambient air pollution [2,10-13]. It is for this reason that we chose to investigate the number of emergency room visits for these three conditions at the AIIMS hospital. Relevant air pollutants having adverse cardio-respiratory effects are TSP, CO, NO, SO, and ozone. The first four are being routinely monitored by the Central Pollution Control Board at six monitoring sites in Delhi, but consistent data on most of the days was available from only one of these sites. It is located in a more heavily polluted central area near a busy traffic intersection. Personal exposures to ambient pollution amongst residents of Delhi are likely to vary widely limiting the validity of these observations. Further, no data on ambient levels of ozone is available in Delhi on a regular basis and the present analysis is limited to only to above-mentioned four pollutants.

Delhi is a highly congested city with an estimated population of over 10 million. It has a large number of government owned as well as private hospitals catering to the needs of not only the residents of Delhi but also the surrounding areas. There are no designated hospitals for area-wise use. It is impossible to define the population served by the AIIMS hospital. The emergency room visits, however, are mainly by patients residing within a distance of 10 kilometers from the hospital. We were constrained to use the data from a single hospital as there is no central registry of hospital admissions, and the outpatient records of other hospitals could not be made available to us. Considering the limitations in the assessment of both exposure and outcome variables, the findings of the present study should be taken as preliminary observations. They are however of sufficient interest since no other reports are available from Delhi.

Counts of events were found to have large dispersion around the mean and the data was not normally distributed. Events requiring emergency room visits are typically rare and are best represented by Poisson distribution. This has been the standard approach by most investigators and was used in the present analysis as well[7]. We used time series analysis with each day as a unit of observation. Temperature and humidity were included in the basic model as explanatory variables which needed to be controlled for. We used population averaged general estimation equation for Poisson family to model events of interest. This method of statistical analysis has been used by several investigators in the recent years[2,4]. Although time series analysis can not establish casualty, the present method of data analysis is expected to define those pollutants which affect cardio-respiratory events after taking other explanatory variables into account.

Emergency room visits for asthma have been related to particulate air pollution (PM,,) by several investigators [12,14,15]. This association has been observed even in regions where particulate concentration did not exceed the ambient air quality standards. The association between SO, levels and asthma admissions has been less consistent[2]. Similarly ambient NO, levels have been reported to have a weak correlation with asthma admissions. Variable findings have been reported by other investigators who observed association between asthma admissions and SO, in children, and with NO, in adults[16]. Although both SO, and NO, were significantly related to emergency room visits for asthma on univariate analysis using Poisson regression, these variables did not significantly add to the predictive power of the model after inclusion of other explanatory variables. Ambient ozone levels, particularly in summer months, have a stronger effect[12]. Since these levels were not measured in this study, some of the variability in asthma admissions would remain unexplained. The findings of the present study suggest that asthma admissions increase by almost 21% due to the ambient levels of pollutants exceeding the national air quality standards.

An association between daily emergency room admissions for COAD and levels of CO, SO, and black smoke has been reported from Barcelona where the levels of individual pollutants were much lower than the standard values[17]. Others have reported an increase in emergency room admissions due to respiratory illness without categorizing it further[10,11]. We observed a significant association between admissions due to exacerbation of COAD and levels of TSP and CO. These findings are significant as the analyses were performed without specifying age groups of the subjects. In terms of burden of disease, COAD admissions are almost half of the asthma admissions, but almost a quarter of them could be attributed to levels of pollutants exceeding the national standards.

Daily time series analysis for cardiovascular hospital admissions and previous day's air pollution has been reported for London[13]. The investigators observed myocardial infarction to be related to black smoke, NO,, CO and SO,. The present study also shows association between acute coronary events and daily levels of TSP and CO so that a quarter of these events could be attributed to the levels of these pollutants exceeding the national standards.

It would be useful to extend these studies to include emergency admissions to all hospitals in Delhi, and analyze their association with daily levels of pollutants measured at all the six monitoring sites. Meanwhile, the preliminary observations reported here emphasize the immense burden of disease in Delhi due to high levels of ambient air pollution.

ACKNOWLEDGMENTS

We thank Dr Malti Goel, Senior Advisor, Department of Science and 'Technology for initiating this project, the Govt. of Japan for donating the monitoring equipment, casualty staff at the AIIMS, and the medical record section, AIIMS for help in collection of data.

REFERENCES

1. Dockery DW, Pope CA, Xu Xi, *et al.* An association between air pollution and mortality in six US cities. N *Engl J Med* 1993; 329 : 1753-59.
2. Schwartz J, Slater D, Larson TV, *et al.* Particulate air pollution and hospital emergency room visits for asthma in Seattle. *Am Rev Respir Dis 1993; 147* : 826-31.
3. Dab W, Medina S, Quenel P, Moullec YL, Terbe AL, Thelot B. Short term respiratory health effects of ambient air pollution : Results of the APHEA project in Paris. *J Epidemiol Community Health* **1996; 50 (Suppl 1) : S 42-6.**
4. Morgan G. Corbett S, Wlodarczyk J, Lecois P. Air pollution and daily mortality in Sydney, Australia, 1989, through 1993. *Am J Public Health 1998; 88 : 759-64.*
5. Lal AK. Environmental status of Delhi. *Indian J Environ Protect* 1996; 16 : l-11.
6. World Health Organisation. Selected methods

of measuring air pollutants 1976, WHO offset publication No. 24, WHO, Geneva, pp 112.

7. Katsouyanni K, Schwartz J, Spix C, *et al.* Short term effects of air pollution on health : An European approach using epidemiologic time series data. The APHEA Protocol. *J Epidemiol Community Health* 1996; 50 (Suppl 1) : S12–8..

8. A Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society. Health effects of outdoor air pollution (Part I). *Am J Respir Crit Care Med* 1996 ; 153 : 3-50.

9. A Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society. Health effects of outdoor air pollution (Part *2). Am J Respir Crit Care Med* 1996; 153 : 477-98.

10. Delfino RJ, Becklake MR, Hanley JA. The relationship of urgent hospital admission for respiratory illnesses due to photochemical air pollution levels in Montreal. *Environ Res* 1994; 67 : 1-19.

11. Delfino RJ, Murphy AM, Burnett RT, Brook JR, Becklake MR. Effects of air pollution on emergency room visits for respiratory illness in Montreal Quebec. *Am J Respır Crit Care Med* 1997; 155 : 568-76.

12. Anderson HR, Leon AP, Bland JM, Bower JS, Emberin J, Strachan DI? Air pollution, pollens and daily hospital admission for asthma in London 1987-92. *Thorax* 1998; 53 : 84248.

13. Paloniecki JD, Atkinson RW, Leon Al’, Anderson HR. Daily time series for cardiovascular hospital admissions and previous day’s air pollution in London, UK, *Occup Environ Med* 1997; 54 : 535-40.

14. Pope CA III. Respiratory disease associated with community air pollution and a steel mill. Utah Valley. *Am J Public Health* 1989; 79 : 623-8.

15. Pope CA III, Dockery DW, Spengler JD Raizenne ME. Respiratory health and PM,, pollution : A daily time series analysis. *Am Rev Respir Dis* 1991; 144 : 668-74.

16. Sunyer J, Spix C, Leon Al’, *et al.* Urban air pollution and emergency admission for asthma in four European cities. The APHEA Project. *Thorax* 1997; 52 : 7605.

17. Sunver J, Anto JM, Murillo C, Saez M. Air pollution on emergency room admissions for chronic obstructive pulmonary disease. *Am J Epidemiol* 1991; 134 : 277-86.

NATIONAL COLLEGE OF CHEST PHYSICIANS (INDIA)

Fellowship/Membership Fee

Membership (Annual)	:	Rs.200.00
Membership (Life)	:	Rs.2000.00
Fellowship	:	Rs.2500.00
Enrolement (For new members only)	:	Rs.250.00

Payments should be made by Cheque/Demand Draft, drawn in favour of the Secretary, National College of Chest Physicians (I). Please add Rs. 30/- to all out-station cheqzzes.

Annual membership is valid for one financial year (April-March) only.

Sd/-
(S.N. Gaur)
Secretary

NATIONAL COLLEGE OF CHEST PHYSICIANS (INDIA)

All the fellows and Members are requested to mention their old address also while informing for change of address alongwith their Fellowship/Membership number to the Secretary, NCCP (I) or to Publication Department, IJCDAS to avoid any mistake/delay in mailing the Journal's copy,